BRITISH ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE

Winnipeg Meeting, 1909.

August 25th to September 1st

Visit to Cobalt and Sudbury

August 17th to August 20th

OFFICE OF THE BUREAU OF MINES, ONTARIO

Mrs. A. R. Whitman

TORONTO:
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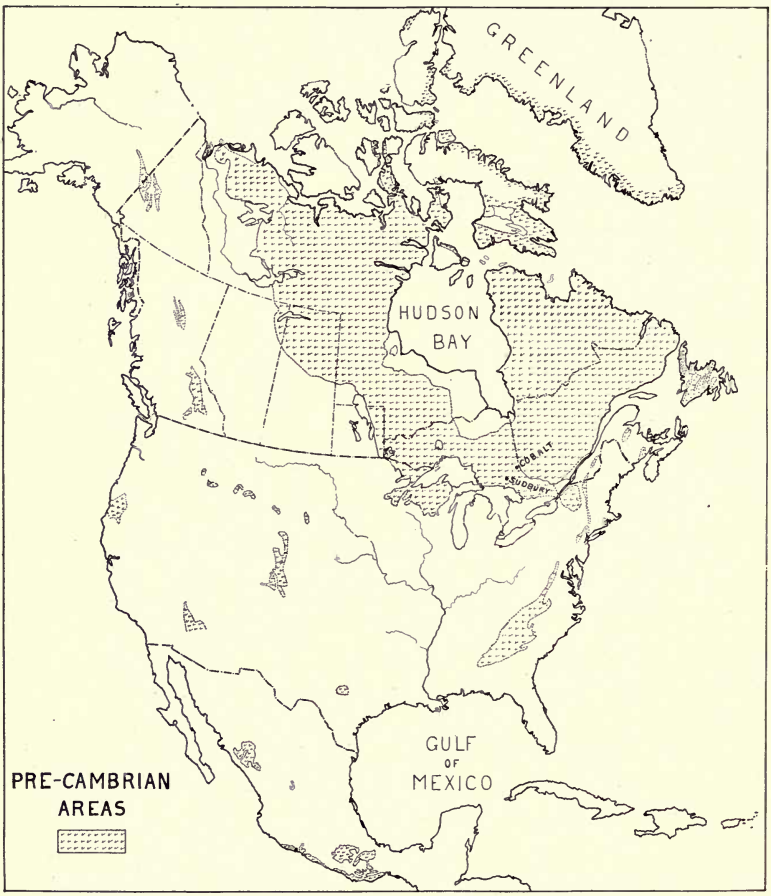

The Pre-Cambrian rocks are more characteristic of Canada, than of other parts of North America.

Geology
Library

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VISIT OF GEOLOGISTS TO COBALT AND SUDBURY.

PRECEDING BRITISH ASSOCIATION MEETING IN WINNIPEG, AUGUST, 1909.

Several members of the British Association for the Advancement of Science, who propose to attend the meeting in Winnipeg next August, have expressed a desire to visit the Cobalt and Sudbury mineral fields during their trip to Canada. The Bureau of Mines of Ontario, in co-operation with the Cobalt Branch of the Canadian Mining Institute and with the mining men of Sudbury, invites especially those interested in economic and pre-Cambrian geology to visit the camps.

Members of the British Association coming to Canada on ships landing at Quebec or Montreal, take the Canadian Pacific Railway from Montreal to North Bay Junction, 360 miles from Montreal, on the way to Winnipeg. Cobalt station on the Temiskaming and Northern Ontario Railway is distant 103 miles by railway from North Bay. Sudbury is on the Canadian Pacific Railway 79 miles west of North Bay.

Persons travelling via New York and Toronto can take through train from from Toronto to Cobalt, distance 330 miles.

A committee of the Cobalt Branch of the Canadian Mining Institute will arrange for the visitors to see mines of the camp and the chief features of geological interest on Tuesday, August 17th, and Wednesday, August 18th. Visitors wishing to come to Cobalt a day or two before the main party will be welcomed. After the trip to Cobalt a visit will be made to Sudbury, probably on August 19th and 20th, unless it is found desirable to spend a day longer at Cobalt or vicinity

Hotel accommodation is to be had at Cobalt and in the nearby towns of Haileybury and New Liskeard. There is also ample hotel accommodation at Sudbury.

The headquarters for the visitors at Cobalt will be the office of Mr. A. A. Cole, Mining Engineer of the Temiskaming and Northern Ontario Railway (the Ontario Government Railway).

The Provincial Geologist of Ontario, (Mr. Willet G. Miller), will be at Cobalt during the visit and will give what information he can concerning the geology of the area. Visitors wishing further information can obtain it by addressing the Provincial Geologist, Toronto, Canada, or Mr. A. A. Cole, Cobalt, Canada.

Visitors while in Montreal can obtain information concerning the mineral resources of Canada at the office of the Canadian Mining Institute, Rooms 3 and 4, Windsor Hotel. Various reports and maps may be consulted in this office.

Persons desiring to make the visit to Cobalt or Sudbury should notify the Provincial Geologist at their earliest convenience so that the proper preparations may be made. Information concerning the meeting in Winnipeg is to be obtained from the Honorary Local Secretaries, British Association for the Advancement of Science, Winnipeg, Canada.

Geology.

Both the Cobalt and the Sudbury camps have been described in the government geological reports during recent years. The chief report on Cobalt is entitled "The Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming," by Willet G. Miller, Provincial Geologist. This report is accompanied by plans and two geologically coloured maps, one on the scale of 1 mile to 1 inch, and the other on the scale of 400 feet to 1 inch with contour intervals of 10 feet.

987887

MAP
OF THE PROVINCE OF
ONTARIO
CANADA.

Two important reports have been published on the Sudbury area, (1) Dr. A. E. Barlow—Report on the Origin, Geological Relations and Composition of the Nickel and Copper Deposits of the Sudbury Mining Division, Vol. XIV., 1901, of the Geological Survey of Canada; (2) The Sudbury Nickel Field, by Dr. A. P. Coleman, Vol. XIV., Part III, Report Ontario Bureau of Mines.

These reports on Sudbury, and that on Cobalt are to be found in many libraries in Great Britain and elsewhere.

The ore bodies at both Cobalt and Sudbury occur in rocks of pre-Cambrian age.

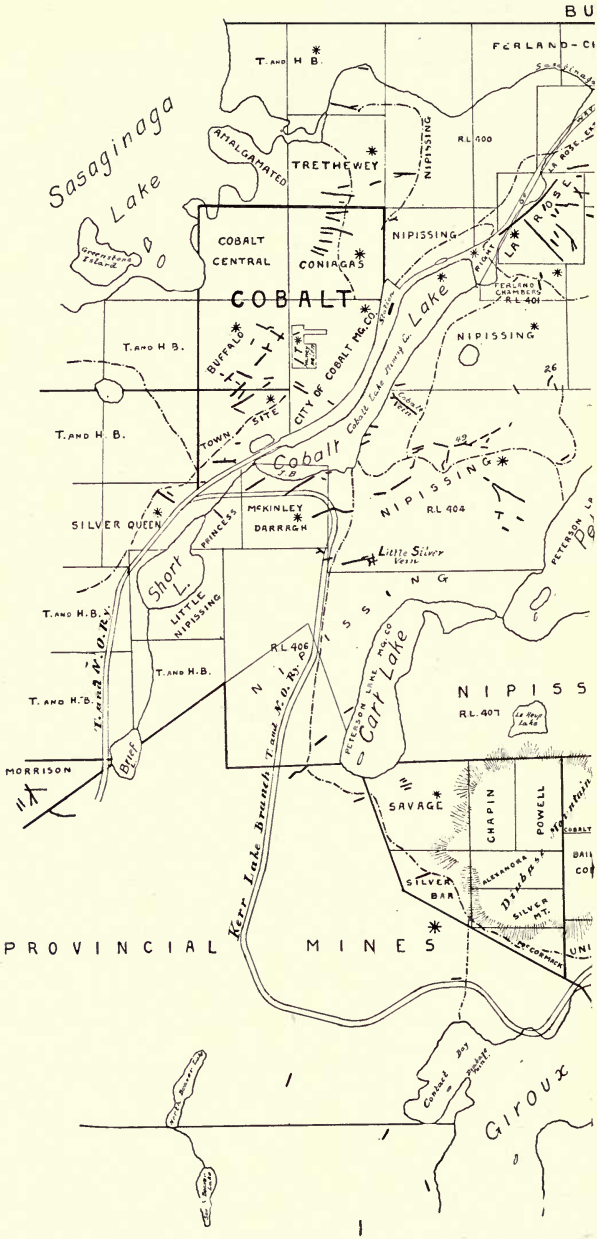
Cobalt is the world's greatest producer of silver, cobalt and arsenic; and Sudbury is the greatest producer of nickel. The Province of Ontario possesses a number of somewhat unique economic minerals: corundum, phlogopite, graphite, feldspar, etc., etc.

The following table shows the mineral output of the Province for 1908:—

Value Mineral Production Ontario, 1908, "refined value basis."

Metallic.	Quantity.	Price.	Value.
Gold	3,465 oz.		$ 60,337
Silver	19,444,400 "	52.864c.	10,543,410
Cobalt	1,224 tons.	75c. lb. CoO.	2,334,175
Nickel	10,175 "	43c. lb.	8,140,000
Copper	7,561 "	13 208c. lb.	1,997,314
Iron Ore	216,177 "		574,839
Pig Iron	271,656 "		4,390,839
			27,770,050
Less Ontario Iron Ore (170,215 tons) smelted into pig iron			456,176
			$27,314,324

Non-metallic.	Quantity.	Value.
Arsenic, refined, tons	702	$ 40,373
" crude "	2,970	
Brick, tile and other clay products		2,806,166
Calcium carbide, tons	2,364	147,150
Cement, Portland barrels	2,022,877	2,417,769
Corundum, tons	106	11,437
Feldspar, "	7,875	20,300
Graphite, refined, tons	10	1,600
Gypsum, tons	10,389	20,778
Iron Pyrites, tons	20,970	69,980
Lime, bushels	2,442,331	448,596
Mica, tons	368	73,586
Natural gas		988,616
Peat Fuel, tons	200	900
Phosphate of Lime, tons	881	7,048
Petroleum, Imp. gals	18,479,547	703,773
Pottery		50,310
Quartz, tons	44,741	52,830
Salt, tons	79,112	488,330
Stone		530,041
Talc, tons	1,016	3,048
		8,882,631
Add metallic		27,314,324
Total Production		$36,196,955



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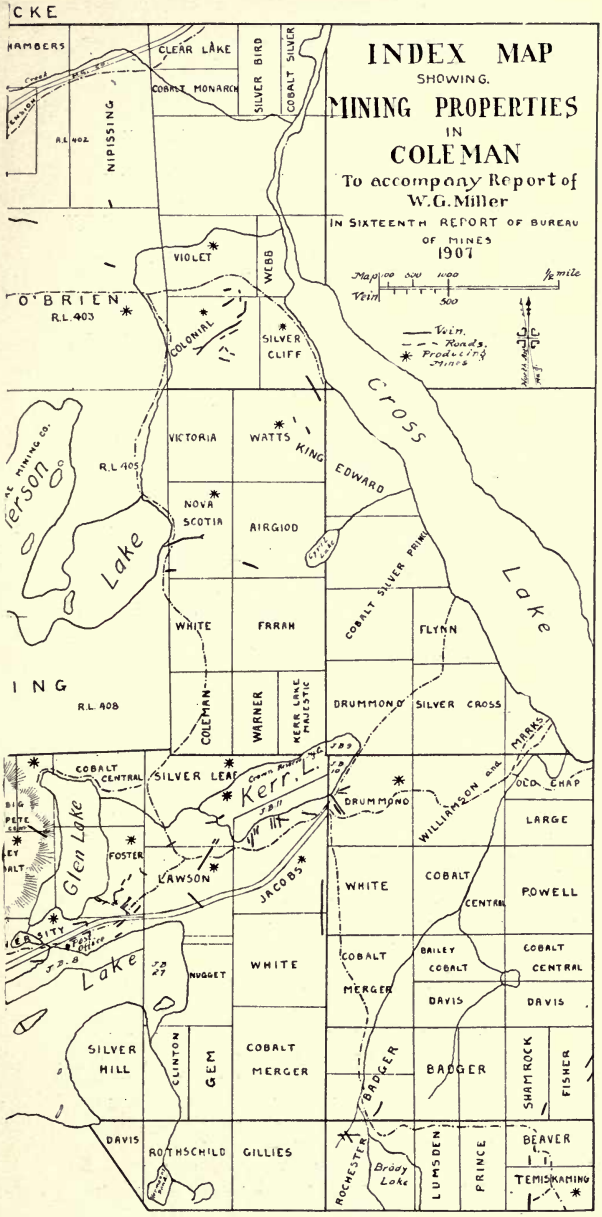
FERLAND-C
T. AND H. B.
Sasaginaga Lake
AMALGAMATED
TRETHEWEY
NIPISSING
R.L. 400
COBALT CENTRAL
CONIAGAS
NIPISSING
LA ROSE
RIGHT
FERLAND CHAMBERS
R.L. 401
COBALT
Greenstone Island
BUFFALO
CITY OF COBALT MG. CO.
Station
Cobalt Lake
NIPISSING
T. AND H. B.
26
TOWN SITE
Cobalt Vein
T. AND H. B.
Cobalt
J.B.
49
NIPISSING
R.L. 404
SILVER QUEEN
McKINLEY DARRAGH
PRINCESS
Little Silver Vein
PETERSON LA
Short L.
LITTLE NIPISSING
T. AND H. B.
T. AND H. B.
T. AND H. B.
T. and N. O. Ry.
R.L. 406
T. and N. O. Ry.
PETERSON LAKE MG. CO.
Cart Lake
NIPISS
R.L. 407
Le Roy Lake
MORRISON
Brief
Kerr Lake Branch
SAVAGE
CHAPIN
POWELL
COBALT
BAIL
CO
ALEXANDRA
SILVER BAR
Diabase
SILVER MT.
McCORMACK
UNI
PROVINCIAL MINES
Contact Bay
Giroux


INDEX MAP
SHOWING
MINING PROPERTIES
IN
COLEMAN
To accompany Report of
W.G. Miller
IN SIXTEENTH REPORT OF BUREAU
OF MINES
1907
Map 100 500 1000 ½ mile
Vein 500
Vein.
Roads.
Producing Mines
CLEAR LAKE
COBALT MONARCH
SILVER BIRD
COBALT SILVER
NIPISSING
R.L. 402
VIOLET
WEBB
O'BRIEN
R.L. 403
COLONIAL
SILVER CLIFF
Cross
Lake
VICTORIA
WATTS
KING EDWARD
R.L. 405
NOVA SCOTIA
AIRGIOD
COBALT SILVER PRINCE
WHITE
FARAH
FLYNN
R.L. 408
COLEMAN
WARNER
KERR LAKE MAJESTIC
DRUMMOND
SILVER CROSS
MARKS
COBALT CENTRAL
SILVER LEAF
Kerr L.
DRUMMOND
WILLIAMSON and
OLD CHAP
LARGE
Glen Lake
FOSTER
LAWSON
JACOBS
WHITE
COBALT CENTRAL
POWELL
Lake
NUGGET
WHITE
COBALT MERGER
BAILEY COBALT
COBALT CENTRAL
DAVIS
DAVIS
SILVER HILL
CLINTON
GEM
COBALT MERGER
BADGER
BADGER
SHAMROCK
FISHER
DAVIS
ROTHSCHILD
GILLIES
ROCHESTER
Brady Lake
LUMSDEN
PRINCE
BEAVER
TEMISKAMING

THE COBALT MINERAL AREA.

(Visit of August 17th and 18th, 1909.)

Cobalt Station, on the Temiskaming and Northern Ontario Railway, is distant 330 miles north of Toronto.

The veins which have made the area known throughout the mining world were discovered during the building of the railway in the late summer of 1903. It was not till over a year afterwards that the railway was completed to what is now known as Cobalt Station.

Briefly, the characteristics of the camp may be described as follows: there are numerous small veins, probably averaging 4 inches in width, with very high values in silver, together with cobalt, nickel and arsenic. The veins occur in rocks of pre-Cambrian age and the index map (see page 8) shows they are numerous. Below is given a list of the minerals in the veins and statistics of shipments.

In prospecting, cobalt bloom, the delicate pink-colored decomposition product of the cobalt arsenides, is looked for. If traces of it are found the rock surfaces, both those which are exposed and those which are soil covered, are carefully examined. Much of the prospecting consists in digging trenches through the soil to the compact rock below. Nuggets of silver, freed from cobalt and nickel minerals by the weathering of the latter, also frequently give evidence of the presence of veins. At times if the veins are covered by drift material the undecomposed veins are found immediately below the soil and show glaciated surfaces.

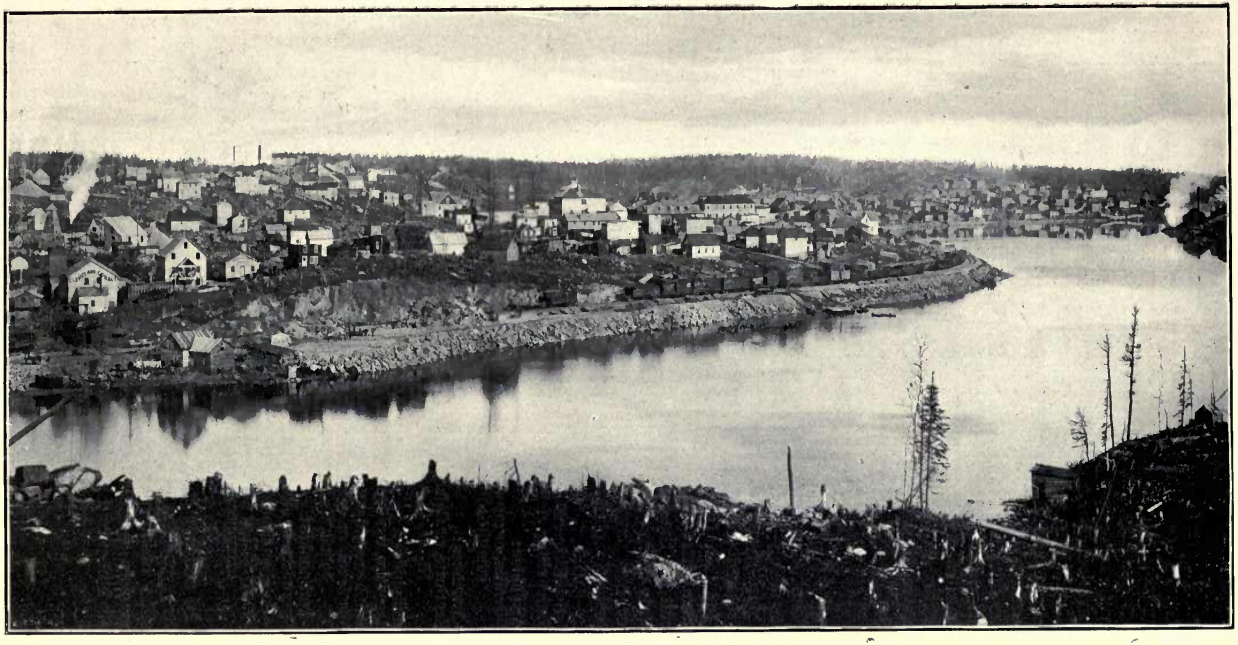
The veins, throughout the six or eight square miles in which those rich in silver are found, show no uniformity in strike, and in nearly all cases their dip is vertical.

There are rocks of three ages in the area in which productive veins have been found. The most of the veins occur in the Lower Huronian conglomerate and graywacké slate. A few are found in the older Keewatin, and a few in the younger diabase. These groups of rocks are briefly described below.

To give an idea of the richness of some of the veins, it may be said that a trench, 30 feet deep and 50 feet long, on one vein whose average width was not over six inches, gave over $200,000 worth of ore. Thirty ton car loads of ore have realized over $100,000. In open cuts and surface workings, it has been estimated that the winning of the ore costs about $100 a ton.

The veins at Cobalt, in regard to their mineral contents, are unique so far as is known in North America. Certain well known deposits in Saxony and Bohemia, and Chalanches in France, have a similar assemblage of ores.

The discovery of the rich ore bodies at Cobalt came at an opportune time for the northeastern part of the Province of Ontario. The Government railway, the Temiskaming and Northern Ontario, is being built northward into a vast territory which needs settlers. Not many miles northward of Cobalt the rocky region, traversed by the railway for the first hundred miles of its course, gives place to a promising agricultural district. Farther north, over the height of land, the railway taps the great clay belt which has been estimated to contain 16,000,000 acres of fertile lands. Cobalt has served, and will serve, as the lodestone to this great region in the vicinity of Temiskaming and northward. Its



Cobalt in 1907, with Cobalt lake in the foreground.

discovery during the building of the railway was thus fortunate. The cobalt-silver veins here serve the purpose which the auriferous placers of Australia, California and British Columbia served in their day. They attract not only miners, but all classes of people, and will thus bring about the settlement of the region much earlier than would the stable yet comparatively prosaic industries of farming and lumbering.

Cobalt has convinced the public that Ontario has deposits of ore richer than are those known in most parts of the world. The discovery in Northern Ontario of economic minerals of any grade of richness will not be doubted in the future. It will be different from the history of Cobalt, which, although described in both the daily press and in technical journals shortly after its discovery, received little attention from the public for nearly eighteen months. If the ore bodies had been in some remote region difficult of access its history as regards recognition would likely have been otherwise. There would have been a stampede to it.

Ores and Minerals.

The more important ores in the veins under consideration are native silver,—associated with which is usually some dyscrasite, argentite, pyrargyrite and other compounds of the metal—smaltite, niccolite and related minerals. Many of the minerals occur mixed in the ores, and for this reason some of them have not been clearly identified. Another character of the minerals which renders their identification difficult, is the fact that most of them occur in the massive form. Crystals when present are small, being almost microscopic in size. The writer has, however, identified the following minerals, which can be conveniently classed under the headings:

I.—Native Elements:
Native silver, native bismuth, graphite.

II.—Arsenides:
Niccolite, or arsenide of nickel, NiAs; chloanthite, or diarsenide or nickel $NiAs_2$; smaltite, or diarsenide of Cobalt, $CoAs_2$.

III.—Arsenates:
Erythrite, or Cobalt bloom, $Co_2\ As\ O_8+8H_2O$: and annabergite, or nickel bloom, $Ni_2\ As_2\ O_8+8H_2O$.

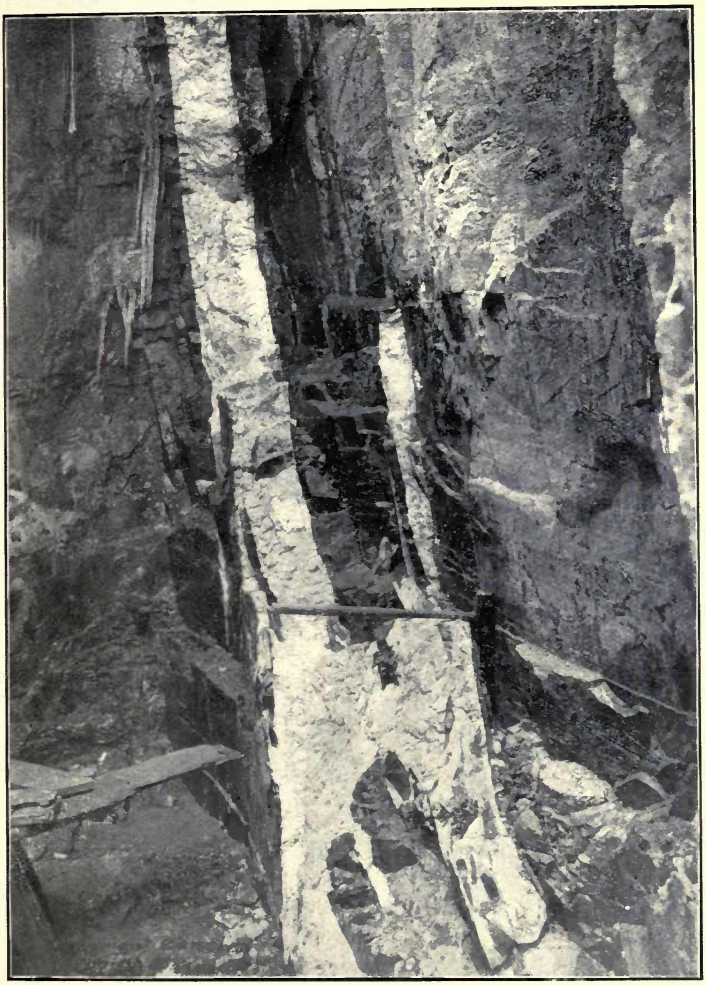
IV.—Sulphides:
Argentite, or silver sulphide, Ag_2S; millerite, or nickel sulphide, NiS.

V.—Sulph-arsenides:
Mispickel, or sulph-arsenide of iron, FeAsS; cobaltite, or sulph-arsenide of cobalt, CoAsS.

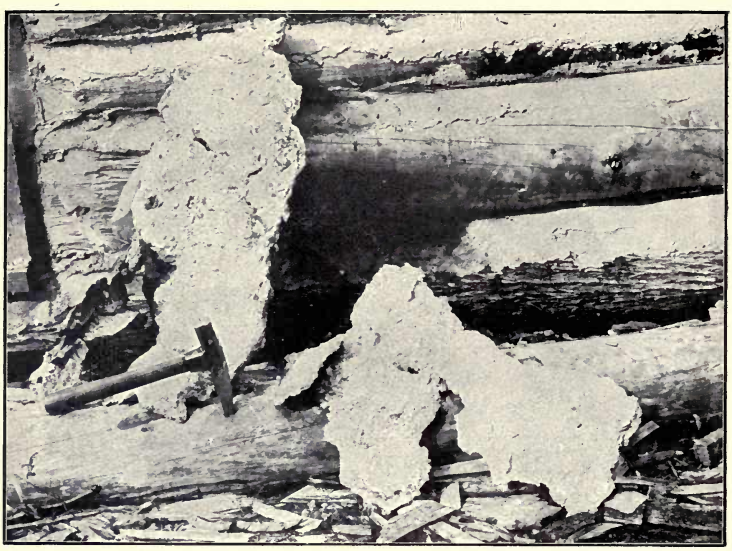
VI.—Antimonide:
Dyscrasite, or silver antimonide, Ag_6Sb.

VII.—Sulph-antimonides:
Pyargyrite, or dark red silver ore, $Ag_3\ SbS_3$; tetrahedrite, or sulph-antimonide of copper, $Cu_8Sb_2S_7$.

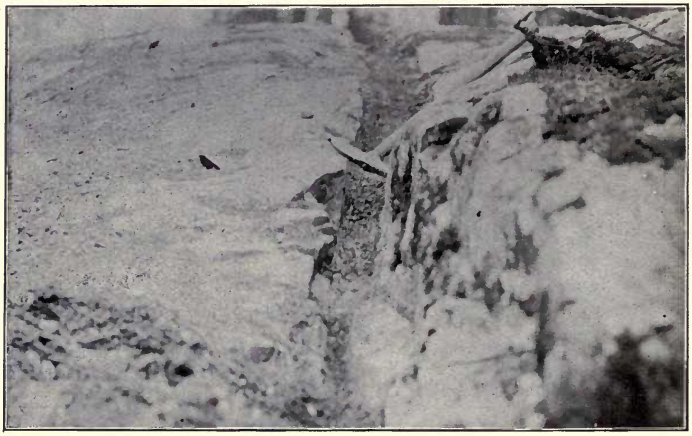
In addition to the above minerals there are a number of secondary or decomposition products with rather indefinite characteristics, such as asbolite, which may be called a much weathered form of cobalt bloom. It consists essentially of the oxides of cobalt, manganese, etc. The cobalt bloom and annabergite occur intermixed, at times, in proportions such that the red color of the former counteracts the green color of the latter, a white clay-like substance being the result. There are occasion-



Crown Reserve vein, on Kerr lake.



Slabs of silver from the Trethewey Mine. The slab standing upright by the hammer weighs 79 pounds and consists of 66.67 per cent. of silver.



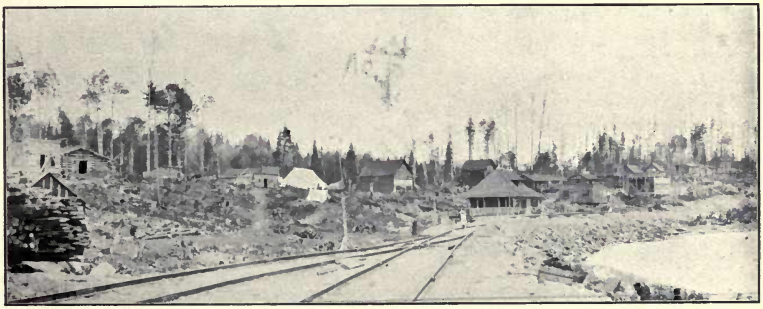
A typical silver-cobalt vein on Coniagas property. The head of the hammer shows the width.

ally other sulphides present than those mentioned, especially in the wall rock. These consist of copper pyrites and bornite, which are the sulphides of copper and iron; galena, the sulphide of lead; and iron pyrites, the disulphide of iron. Zinc blende is found occasionally. These

minerals in the wall rock were probably deposited before the vein materials. It is said that the minerals stromeyerite, argyropyrite and freibergite have been found in some of the veins.

One is struck with the great variety of these comparatively rare minerals, some of which occur in a high percentage in the deposits. The number of metals is also large.

A characteristic of the group is the subordinate part which sulphur plays in comparison with arsenic. Antimony, which is not abundant, is found in some compounds where we would expect to find arsenic, since the latter is so much more abundant. For instance, while we have both native silver and arsenides in abundance, no compounds of arsenic and silver have yet been recognized, although they are probably present. Then one would also expect to find some compounds of bismuth since this metal occurs in the free state in considerable quantities in some parts of the deposits. It might also be expected that native arsenic would occur at times.

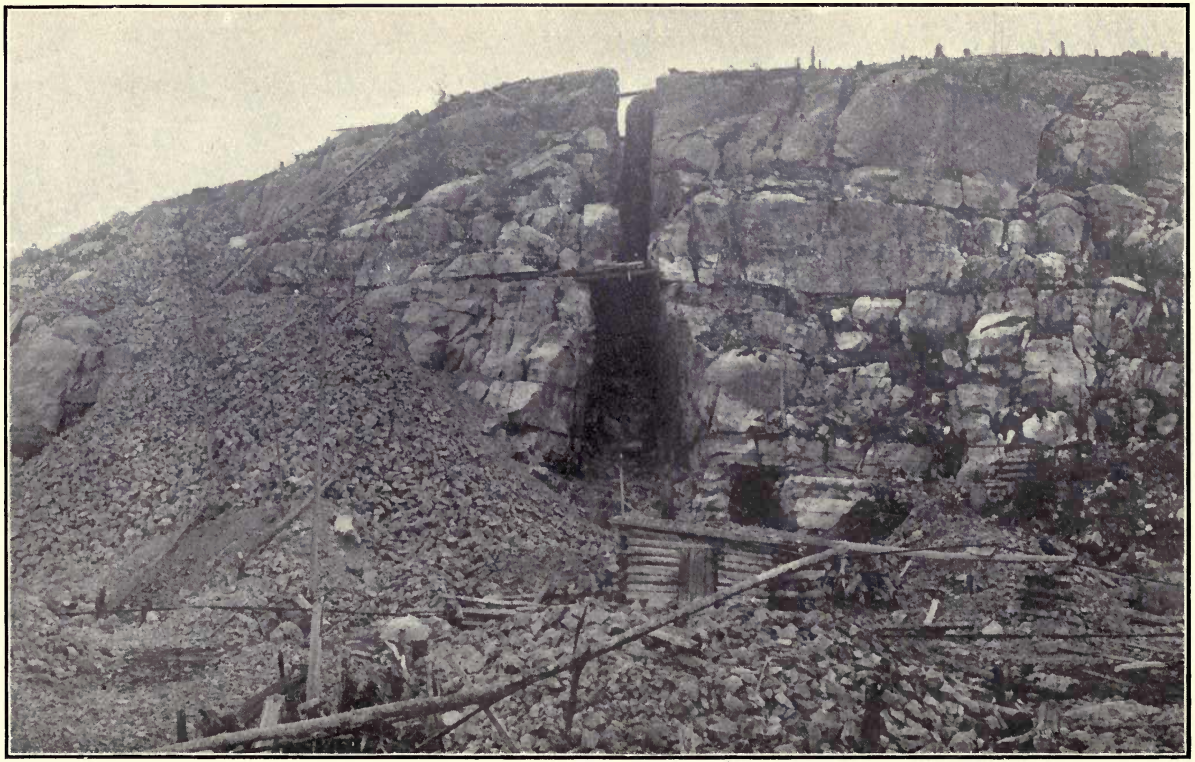


Cobalt Station, June, 1905.

It will be seen that nearly all the chemical groups of minerals found in the celebrated Joachimsthal deposits of Bohemia are present in the Temiskaming ores. The most important exception is uraninite or pitchblende, which came into prominence a few years ago on account of its being the chief source of the element radium.

The Bohemian deposits appear never to have been so rich in silver, cobalt, nickel or arsenic as are those of Ontario.

The finding of such rich ore within so short a distance of the shore of Lake Temiskaming, a stretch of water which has been a well-travelled route to the north by white men for two hundred years or more, and the deposits being only about five miles from the Town of Haileybury, show the possibilities there are for the discovery of important mineral-bearing areas in the vast hinterland of Ontario, much of which is little known. The first of these ore bodies to be worked lies within half a mile of what is now known as Cobalt Station, distant by rail 103 miles from North Bay junction on the transcontinental line of the Canadian Pacific, and 330 miles almost north of the City of Toronto. It may also be added that one of the oldest known ore bodies in North America, the argentiferous galena on the east side of Lake Temiskaming, is distant only eight or nine miles from Cobalt Station. This galena deposit was apparently discovered by voyageurs 150 years ago. A map



The Little Silver Vein, southwest corner of location R. L. 404. The cliff is about 70 feet in height, and is composed of almost orizontally lying Lower Huronian rocks. At the bottom are about 15 or 20 feet of well banded greywacké slate. This is followed by about the same thickness of fieldspathic quartzite, overlying which, at the top of the cliff, is a coarse conglomerate. The greatest thickness of the vein, as originally exposed, was about 8 inches. The strike is east and west, and the dip, as the photograph shows, is almost vertical.

of the lake published in 1744 has a bay marked on it with the name "Anse à la Mine," thus showing that the deposit was known at least at that date, and probably much earlier, owing to the fact that the ore outcrops at the water's edge and is of such a character as to attract attention.

Rocks of the Cobalt Area.

**Keewatin and Laurentian*: The oldest series in the district consists of an igneous complex which contains diabases, and related rocks of different periods of eruption, together with granite-porphyry and

Contact on shore of Temiskaming between the Keewatin and Lower Huronian. The Huronian breccia rests on the Keewatin rock from which it was derived. Lot 15 in the second concession of Bucke.

other igneous material. Sediments are represented by the jasper-iron ores. The basic rocks or greenstones occur in much larger volume than do those of a more acid character. The name Keewatin is applied to this series. It has been subjected to folding and other disturbances, and is cut through by medium to coarse-grained granite, especially in the township of Lorrain, to which the name Laurentian is applied. The Keewatin rocks, however, have been folded before the intrusion of the Laurentian.

*The Keewatin and Laurentian complex bears a relationship to the Huronian similar to that which the Lewisian bears to the Torridonian of Britain.

Huronian: After the Laurentian intrusion the surface was subjected to erosion, and these rocks, together with those of the Keewatin, were worn down. This period of erosion was a long one, and the surface was rendered very uneven, being cut into hills and valleys somewhat like those of the present surface. The oldest fragmental material which lies directly on the eroded Keewatin and Laurentian surface consists of conglomerates, greywacké-slate and impure quartzites. These rocks contain fragments of the granite, greenstone and other representatives of the older series, and their relationship to the latter is quite easily proved by contacts in a number of localities. This older, or, as it is called on the map, Lower Huronian, is of special interest since it contains most of the cobalt-silver veins.

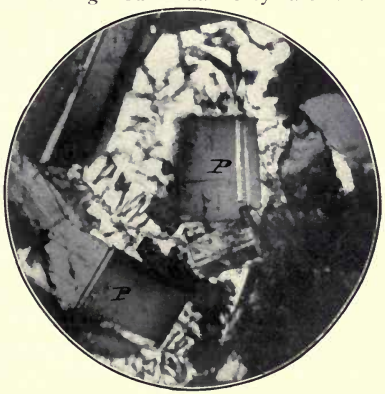
Torsion cracks in Keewatin greenstone. Lot 15 in the second concession of Bucke.

The association of the members of the Lower Huronian is somewhat variable. There is usually a little coarser material, conglomerate, at the base. This is frequently followed by a considerable thickness of well banded greywacké-slate. The slate in many cases passes gradually upwards into a feldspathic or impure quartzite which is succeeded by a coarse conglomerate. The greater part of the conglomerate is undoubtedly younger than the more slaty members. The relationship of these members of the Lower Huronian is well seen in the Little Silver vein cliff on the Nipissing property. (See page 16).

The veins cut through all these series, but the most productive parts of the veins are usually in the rocks which contain more or less coarse fragments. It is believed that the fissures now occupied by these veins were produced at the time of the eruption of the younger, or post-Middle Huronian diabases, which will be referred to again.

This Lower Huronian series has at one time had a greater thickness than it has at present. Being laid down on an uneven surface, it is impossible to say what the thickness of the series is at any one point; it may be a few feet or it may be a few hundred feet. In some places it is entirely absent, the older series or floor on which the Lower Huronian is laid being exposed at the surface. The hills near Cobalt Station, however, where these conglomerates and other members of the series outcrop, are 500 feet above the water level at the shore of Lake Temiskaming, where similar outcrops are found. It would thus seem that the Lower Huronian may in some cases have a thickness of at least 500 feet. Certain outcrops of the conglomerate bear a striking resemblance to glacial boulder deposits.

Middle Huronian: The series of arkoses, or what have been called by some writers sea-green quartzites, together with conglomerates and quartzites of the township of Lorrain, form another series in the Huronian, the present writer having found that they are unconformable to the



Quartz-diabase, showing plagioclase (labradorite) P imbedded in a micrographic intergrowth of quartz and feldspar. From diabase point Giroux lake.

Lower Huronian. This series in the eastern part of the area has been derived chiefly from the erosion of the Lorrain granite, and much of the area, between Chown and Goodwin Lakes on the west and Paradis Bay on the east, contains small patches and outliers of this series. It is impossible to represent these on the map, the passage from granite into the decomposition products being so gradual. On lot 4, in the twelfth concession of Lorrain, a striking contact between the Lower Huronian and Middle Huronian is seen, fragments of slate of the former being cemented in the arkose of the latter.

On the eastern shore of Temiskaming the two series, so far as seen, appear to be conformable.

There is no reason, so far as the writer knows, why this Middle Huronian should not contain veins as well as the Lower Huronian, since it is also cut by the diabase and has been subjected to similar disturbances. The intrusive nature of the diabase as regards the Middle Huronian is seen on the shore of Temiskaming just south of Devil's Rock.

Post-Middle Huronian Diabase: It will be seen from the map that these rocks occupy a considerable part of the surface of the area under review. In most cases, where associated with the Huronian, they seem to be in the form of sheets or sills spreading between or over the layers of the rocks through which they cut. They show no evidence, such as amygdaloidal texture, of being surface flows. These rocks are much fresher in appearance and coarser in grain than those of a similar composition which occur in the Keewatin, and can thus usually be readily distinguished in the field from the latter. After the eruption of these diabases, whose exact age is not known, that is, whether they belong to the Upper Huronian or the Keewenawan, erosion of the surface again took place for a long period of time, and all the series now exposed in the field, with the exception of the younger Niagara, were worn down.

Diabases representing several periods of eruption, Keewatin to post-Middle Huronian, are found, and it is very difficult at times to distinguish them in the field. On the south shore of Cross Lake the diabase which contains cobalt-silver veins is cut by a younger basalt.

Niagara: This Silurian series consists of similar rocks and fossils to those which are found in the districts to the south. It is composed essentially of limestones which contain a little conglomerate and sandstone at their base. The region has been subjected to little disturbance since the deposition of these Niagara rocks.

Glacial and Recent: Much of the surface of the area covered by the map is occupied by boulder clay and loose bedded deposits. The distribution of these materials has not been shown on the smaller scale map, but it is shown on the larger scale one.

Statistics of the Cobalt Area.

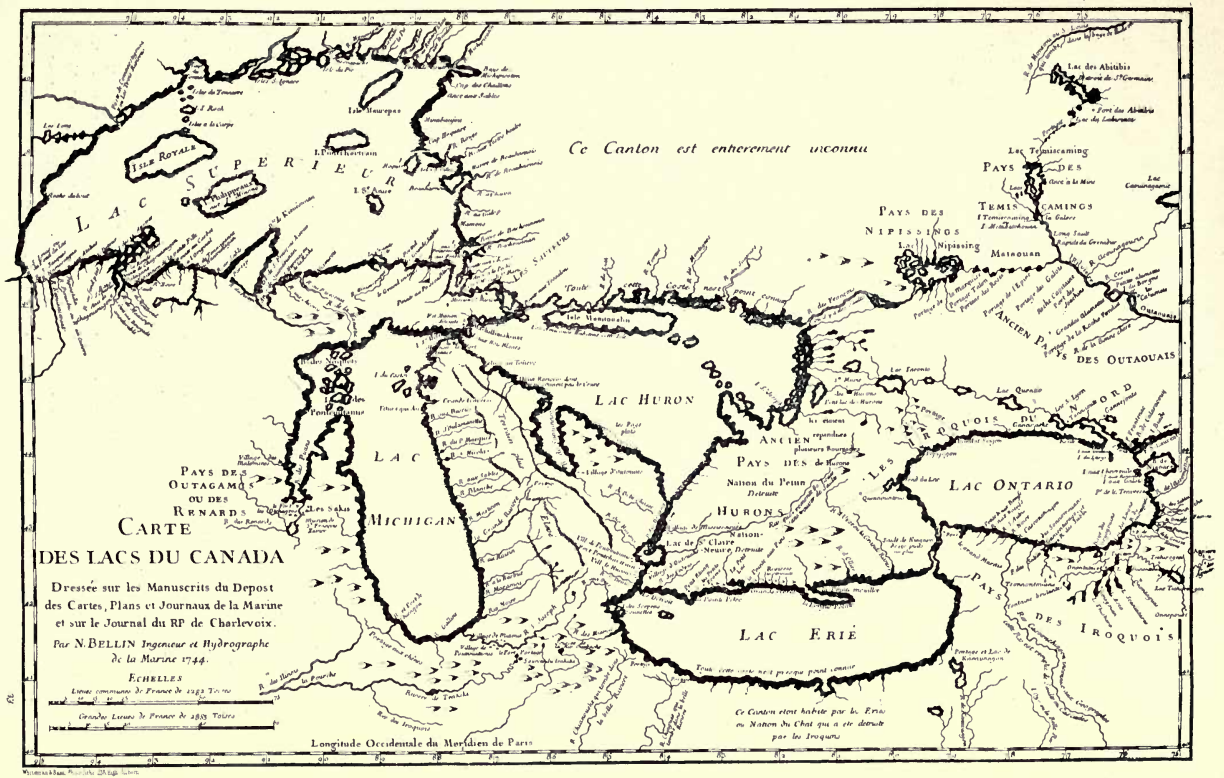
Production.

The first public announcement of the discovery of the camp was made in November, 1903. In September, 1904, the railway from North Bay had been completed, and the shipments from the camp by the end of the year amounted to 158 tons, valued at $136,217, an average of $862 a ton. The value of the shipments during 1905 to 1908 is shown in the following tables:

	1905.		1906.	
	Quantity.	*Value.*	*Quantity.*	*Value.*
Silver, ounces	2,451,356	$1,360,503	5,401,766	$3,667,551
Cobalt, tons	118	100,000	321	80,704
Nickel, tons	75	10,000	160	.....
Arsenic, tons	549	2,693	1,440	15,858
Total		$1,473,196		$3,764,113

	1907.		1908.	
	Quantity.	*Value.*	*Quantity.*	*Value.*
Silver, ounces	10,023,311	$6,155,391	19,437,875	$9,133,378
Cobalt, tons	739	104,426	1,224	111,118
Nickel, tons	370	1,174	612	.....
Arsenic, tons	2,958	40,104	3,672	40,373
Total		$6,301,095		$9,284,869

The mine owners received $20,959,490 for the ore shipped from Cobalt to the end of 1908. This includes $136,217 worth of ore shipped in 1904. The refined value of the metals is, of course, considerably higher.



Map published in 1774 showing that the argentiferous galena deposit on the east side of Lake Temiskaming (Ance à la Mine) was known at that date.

Uses of Cobalt.

The characteristics of the metal cobalt and its compounds are much like those of nickel and its compounds the methods used for extracting one metal from its ores are similar to those employed in the case of the other.

Little cobalt is used in the metallic form, owing to the fact that nickel serves practically the same purposes as metallic cobalt and is much lower in price. It is said that a little cobalt added to nickel in plating tends to produce a more silvery and less steel-like lustre. By far the largest consumers of cobalt are the potteries.

TEMAGAMI.

(Distant 31 miles south of Cobalt.)

Lake Temagami, with its numerous islands and bays and its shores covered with evergreen timber, is one of the most beautiful sheets of water in North America. It is situated in the Government Forest Reserve, and since the completion of the Temiskaming and Northern Ontario Railway, three or four years ago, the lake has become very popular with tourists and sportsmen. Fish and game are abundant in the vicinity of Temagami and the numerous adjacent lakes and streams. The locality is especially noted for moose and for bass and trout fishing.

Near Temagami Station there are exposures of Keewatin and Huronian rocks. Within a half mile northward of the station an iron range of interbanded magnetite and jasper, which has a width of several hundred feet, is to be seen. Two or three miles northward there are deposits of mispickel, pyrrhotite, and copper pyrites. The last-named mineral is also found near the lake.

There are three hotels on Temagami. Steamboats supply transportation facilities.

THE SUDBURY NICKEL-COPPER AREA.

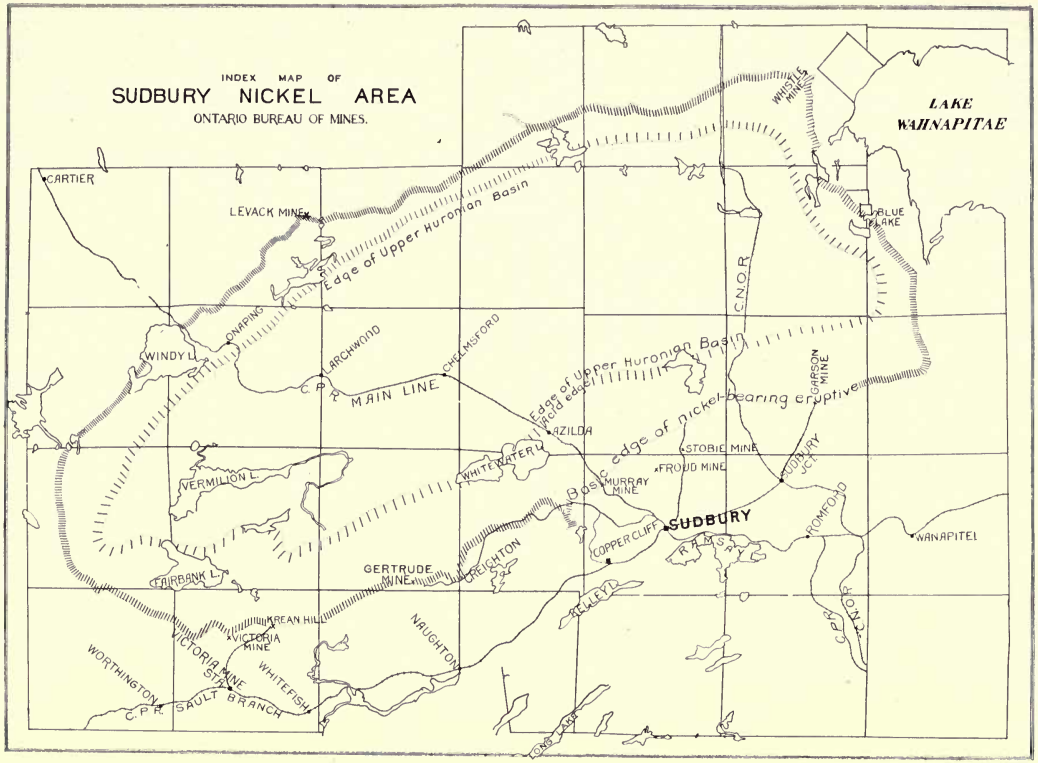
(Visit of August 19th and 20th, 1909.)

The Sudbury mineral area, the world's greatest producer of nickel, which may be called the metal of defence since it is now used by all navies in alloy with steel for armor plate, is distant 262 miles by railway from Toronto.

Two important reports have been made on the Sudbury area during recent years. 1, Dr. A. E. Barlow, Report on the Origin, Geological Relations, and Composition of the Nickel and Copper Deposits of the Sudbury Mining District, Vol. XIV., 1901, of the Geological Survey of Canada. 2, The Sudbury Nickel Field, by Dr. A. P. Coleman, Vol. XIV., Part III., Report of Ontario Bureau of Mines, 1905.

The following notes are taken from Dr. Coleman's Report:

"The Sudbury nickel field has long been known as the most important source of that metal in America, if not in the world, but the work of the last three years has brought out more and more strikingly the unique character of this mining region. It has been proved that all the ore deposits of any economic importance are at or near the outer


INDEX MAP OF
SUDBURY NICKEL AREA
ONTARIO BUREAU OF MINES.
LAKE WAHNAPITAE
CARTIER
LEVACK MINE
Edge of Upper Huronian Basin
WHISTLE MINE
BLUE LAKE
C.N.O.R.
ONAPING
WINDY L.
LARCHWOOD
CHELMSFORD
C.P.R. MAIN LINE
Edge of Upper Huronian Basin
Acid edge
GARSON MINE
AZILDA
Basic edge of nickel-bearing eruptive
STOBIE MINE
FROUD MINE
SUDBURY JCT.
WHITEWATER L.
VERMILION L.
MURRAY MINE
SUDBURY
ROMFORD
WANAPITEI
COPPER CLIFF
RAMSAY
GERTRUDE MINE
CREIGHTON
FAIRBANK L.
KELLEY L.
C.P.R.
C.N.O.R.
KREAN HILL
VICTORIA MINE
NAUGHTON
WORTHINGTON
VICTORIA MINE STA.
WHITEFISH
C.P.R. SAULT BRANCH
LONG LAKE

margin of a huge laccolithic sheet of eruptive rock a mile and a quarter thick, 36 miles long and 17 miles wide. This sheet is now in the form of a boat-shaped syncline, with its pointed end to the southwest and its square end to the northeast. The rock composing this sheet is norite at the outer (and lower) edge, merging into granite or grano-diorite at the inner (upper) edge. The ore bodies are round the margin of the norite or along dike-like offsets from it, and have evidently segregated from the rock while still molten, though they may have undergone later rearrangement by circulating water.

"It is common to find ore deposits associated with eruptive rocks in such a way as to suggest that the eruptive furnished the ore; but in a large majority of the examples described the ores themselves have been transported and deposited by circulating water. In the Sudbury region, however, there is good reason to believe that the ore accumulated at the edges of the eruptive sheet while it was still fluid enough to permit the segregation and sinking of the heavier ingredients, probably, in part at least, under the action of gravitation. At a later time, however, there was in many deposits a considerable amount of water action, particularly in those along offsetts. The conditions just mentioned are of very great interest, both from the geological and the economic side, and the evidence regarding them will be given in detail at a later stage.

"While special attention was paid to the great eruptive sheet and its ore bodies, the adjoining rocks also have been collected and to some extent carefully studied and mapped; but this work has been subordinated to the main object of the investigation. It has been found that everywhere the laccolithic sheet rests on ancient, mainly crystalline, rocks which have hitherto been mapped and described as Laurentian and Huronian, while its upper surface underlies a series of later rocks which Dr. Bell suggests may be Cambrian in age. This inner rock series consists entirely of sediments, mainly ordinary clastics, such as conglomerate, slate and sandstone, but near the base including much pyroclastic materials, volcanic ash, lapilli, etc. These stratified rocks have been bent into synclines and anticlines during the formation of the main syncline. The underlying more ancient rocks present much less regularity, and their relationships are less certain. The rocks mapped as Huronian are chiefly sediments such as quartzite and greywacké tilted into positions more or less approaching the vertical, and often recrystallized into schists. With them are basic eruptives of great variety, including lava flows and an older, more basic, norite than that of the nickel-bearing rock. The rocks mapped as Laurentian include granite and gneiss younger than the Huronian, but older than the nickel-bearing eruptive and the overlying sediments. The youngest rocks of the region are the laccolithic sheet connected with the nickel ores and certain still later dikes of olivine diabase and granite.

"It will be seen that the region presents a wide range of interesting features to the mining engineer as well as to the geologist, and the recent developments in the way of mining operations and the making of wagon roads and railroads enable one to study its southern side in a very satisfactory way; but the northern half is still forest covered for the most part and rather inaccessible.

"The mining community and prospectors are accustomed to speak of two nickel ranges, the main or southern one, and the northern one. Our mapping proves that there is really only one range, which is con-

tinuous with the outer edge of the sheet of nickel-bearing rock. However, in a modified sense the two ranges may still be distinguished, since the extreme west and the extreme east of the laccolithic sheet have not yet disclosed ore bodies of importance. In a general way there are more numerous and larger ore bodies, so far as known, on the southern than on the northern range, though there is great irregularity in this respect on both ranges.

"As will be shown later, the topography of the region has very close relations with the arrangement of the laccolithic sheet and its adjoining rocks, so that the surface forms of the area give aid in studying its geology.

"Nickel ore was first found in what is now the Sudbury district in 1856 by Murray, who obtained it near the present Creighton mine, where Salter, an early land surveyor, had noted great disturbance of the compass. Dr. Sterry Hunt analyzed the material, finding in it nickel and copper. No further discoveries of nickel ores were made until the Canadian Pacific Railway was constructed in 1883, when the ore body of the Murray mine was disclosed; and in the following year the Stobie, Copper Cliff and other deposits. The mineral which attracted attention was, however, the copper pyrites and not the pyrrhotite, and the deposits were valued only for their copper contents, as the name of the famous 'Copper Cliff' mine suggests. It was not till three or four years later, when some thousands of tons of ore had been shipped for treatment from the latter mine, that the value of the nickel ore was recognized.

"Table of Formations in Sudbury Region.

"The succession of rocks in time is given in the following table:

PLEISTOCENE.....	Sand and clay.	
KEWEENAWAN....	Latest granite dikes.	
	Olivine diabase dikes.	
	Granite.	
	Sudbury nickel-bearing eruptive.	
ANIMIKIE.....	Chelmsford sandstone.	
	Onwatin slate.	
	Onaping tuff.	
	Trout Lake conglomerate.	
ARCHEAN.....	Laurentian..	Granitoid gneiss.
	Huronian....	Acid and basic Huronian eruptives.
		Ramsay Lake greywacké-conglomerate.
		Copper Cliff arkose.
		McKim greywacké.

Character of the Sudbury Ores.

"The ores of the Sudbury mining district are extraordinarily uniform, three sulphides only making up practically the whole of most of the ore bodies, and only two as a rule presenting themselves to the eye, pyrrhotite or magnetic pyrites, and chalcopyrite or copper pyrites. The third one, pentlandite, is much the most important, though commonly invisible in the ore except at a few of the richer mines, where it appears only occasionally.

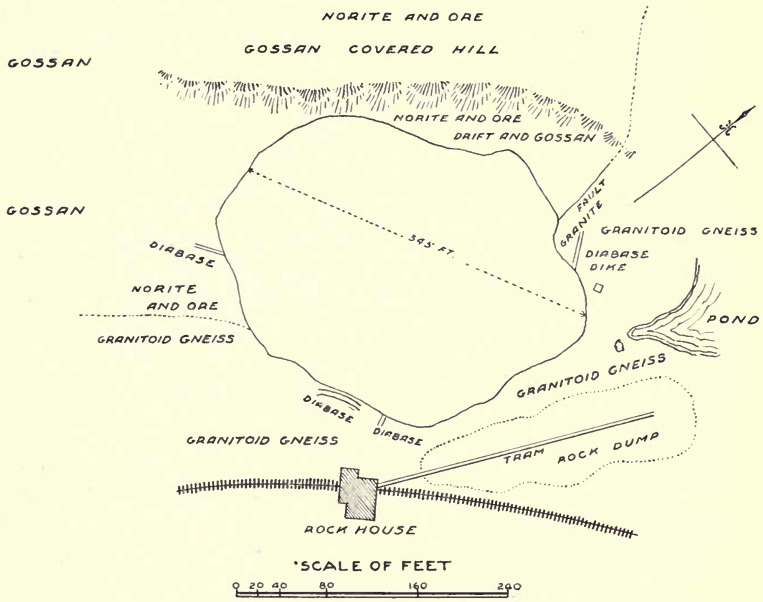
The Creighton Mine.

"The most important nickel mine in the district and one may safely say also in the world, is the Creighton; and it will be desirable to consider in some detail the character of the ore body and its relationship to the enclosing rocks. From the map it will be seen that the Creighton mine is not in Creighton township, but near the middle of lot 10, con. 1 of Snider, though the ridge of gossan-covered norite just to the north of the mine runs southwestward into lot 1 of Creighton. The position of the mine with reference to the margin of the eruptive is of particular interest, since it probably accounts for the unusual size of the ore body. The present great open pit is at the southeastern corner of the largest and deepest bay of the norite along the southern range, and the width of the eruptive is here at its greatest, $4\frac{1}{8}$ miles. Here also we have the greatest width of the whole basin, as measured from Creighton to the Levack mine. This bay of the norite lies between the two great southern offsets at Victoria Mine and Copper Cliff, but nearer to the larger one at Copper Cliff. We may suppose that the greatest amount of the fluid ore accumulated beneath the greatest thickness of overlying magma and was caught in the extreme end of the bay, which had no funnel-shaped outlet along a plane of faulting to allow the ore to escape and push up as separate ore bodies along an offset, as we find in the two cases mentioned. The theory given here is practically the view adopted years ago by some of the best prospectors of the region, though they contented themselves with the observation that one is most likely to find a good body where the "diorite" makes these bay-like projections.

"The norite to the north of the mine is of the usual kind, coarse, dark gray and containing blebs of quartz and flakes of biotite; but in many places it is more or less mixed with strips of greenstone squeezed into schist, or masses of what appears to be diorite; and near the contact granite, porphyritic granitoid gneiss and arkose are enclosed also. Even hundreds of yards to the north some pitting of the surface is noticed, due to the weathering out of spots of ore, and this increases till the edge of the ridge facing southeast is reached, where much of the norite and the included blocks of other rocks is covered with gossan. This is not, however, uniform, but runs in short bands parallel to the edge of the hill, one band ending and another beginning a little above or below, suggesting a corresponding banding of the blebs of ore in the rock. At the base of the hill is a narrow strip of swamp, ending towards the east in a small lake, and the large pit is between the two. Evidently the boggy depression represents ore which has been weathered and removed.

"The rock to the southeast is coarse flesh-colored granitoid gneiss, often porphyritic, containing occasionally masses of greenstone and cut by finer grained syenite or gneiss. These rocks just beyond the open pit and the swampy strip which represents the westward continuation of the ore rise little above the flat, but one or two hundred yards beyond form steep and rugged hills much higher than the norite ridge to the northwest. The hill behind the village shows an extraordinary mixture of rocks, coarse porphyritic granite, well banded gneiss, hornblende schist, hornblende porphyrite and a medium grained grey eruptive, the whole cut by faults which sometimes formed crush conglomerate or breccia containing several kinds of boulders.

"The great open pit of the Creighton mine affords the best opportunity for studying the intimate relations of ore and rock to be found in the region. The original pit was 60 feet deep and almost in solid ore, but as it was enlarged to the northeast, northwest and southeast more rock was encountered, as the ore body dipped northwest beneath a mixture of norite and ore. To the southeast is the irregular wall of coarse granitoid gneiss, which bends sharply in a direction a little west of north. During the past year a second level has been opened 80 feet below the first on the dip of the shaft, which is 60°, and toward the end of the summer a beginning was made at opening up the whole pit to that depth.



CREIGHTON OPEN PIT JULY 1905.

"The open pit shows three main types of rock, the oldest, granitoid gneiss, with a very uneven surface forming a rectangular enclosure for the ore body, next in age norite mixed in all gradations with pyrrhotite and chalcopyrite, and finally diabase dikes, often very porphyritic, penetrating in various directions gneiss, ore and norite impartially. All of the rocks mentioned have undergone more or less faulting and crushing, and fragments of the two older rocks are often enclosed in ore as a sort of breccia, but not of the diabase, though the latter also has been fractured in places and faulted in a small way, producing slickensided surfaces. The dikes have a fine-grained or compact selvage against norite and gneiss, and an almost glassy selvage against ore, showing

that the ore was cold when the dikes were formed, and being a good conductor chilled the surface sooner than the rocks. The ore mixes in such a way with the norite that the conclusion cannot be avoided that the two materials existed in a state of fusion together. From norite with disseminated specks of ore all transitions are met to ore containing tiny scattered crystals of feldspar, or less often the dark minerals; and thin sections prove that the rock-bearing minerals are exceedingly fresh, even the hypersthene, which readily suffers change and is completely altered to secondary hornblende in the norite north of the mine. The mixture cannot then be the result of replacement of rock minerals by ore through the action of water.

"On the other hand the ore is never intimately mixed with the granitoid gneiss, though it may penetrate it a little way as irregular seams, nor is it found in the diabase dikes, except as thin films between slickensided surfaces. That the ore was there in the beginning, arriving as an ingredient of the norite, is very clear, but since then certain changes have taken place on a small scale by circulating waters. Part of the faulting shown by the older rocks may be later in date than the cooling and consolidation of the ore, the latter, as the softer material, adjusting itself between the blocks. This may account for the curious "horse" of granitoid gneiss at the northeast side of the pit, which seems to have slipped down into the ore, though it might be equally well explained as slipping down into the pasty mixture of half cooled norite and ore before the final consolidation.

"From the faulting and irregularity of the contact of the ore with the granitoid gneiss, it is rather hard to determine the original dip of the Archean surface over which the nickel-bearing norite spread, but drill holes to the northwest and west show that the floor dips in the main about 40° to the northwest. How far the great sheet of ore extends beneath the norite in that direction is unknown, though the results of drilling prove the existence of millions of tons. Up to the present the mine has produced about half a million tons of ore, and for some months of the past year averaged 5 per cent. of nickel and 2 of copper, the great value of the mine is apparent."

Since the above was written in 1904 by Dr. Coleman, important changes have taken place at the Creighton Mine. The mine is now equipped with one of the finest plants to be seen anywhere. Electric power is derived from the company's water power some miles distant. The hoisting capacity will soon be about 4,000 tons in twenty-four hours. The power house, dry and bath house, and office and store house are fireproof buildings, and have been constructed according to the latest and most approved designs.

Nickel Steel.

"Secretary Tracy ordered a nickel-steel armor plate made at the famous Creusot Works in France, and also a plain steel plate made at the same works, and a plain steel plate made at the works of Cammel & Company at Sheffield, England, such as was then used on British vessels of war. These plates were brought to the Government proving grounds at Annapolis, Maryland, and set up side by side and fired at, at short range, by eight-inch guns.

"The victory of the French nickel-steel plate was so complete over both the French and English plain steel plates that the trial and tests were heralded by telegraph and cables all over the civilized world.

"Tracy, by this Government test, sent all the common steel armor plates to the junk heap, and completely revolutionized the offensive and defensive efficiency of the navies of the world. Scarcely had the sound of the guns at Annapolis died away before Congress in an hour, at the request of the Secretary of the Navy, General Tracy, voted an appropriation of $1,000,000 to purchase nickel matte at Sudbury to be used in the manufacture of nick-steel armor plate for the United States Navy. This million dollar appropriation by the United States Government and the use of nickel in steel advertised the Sudbury mines over all the commercial world. It saved the Canadian Copper Company from the expense of making any tests of nickel alloys, for they were all made by the Government. In short, the Government's action through the Secretary of the Navy put a new enterprise upon its feet. The Government changed the then existing contracts with the Bethlehem Steel Company from plain steel plates to nickel-steel plates. It entered into contracts with the Carnegie Steel Company for the manufacture of nickel-steel plates, under which contracts millions of dollars were expended in building the famous Homestead works. The small experiments in the Washington Navy Yard in 1876 have grown to the proportions of covering every first-class war ship in the navies of the world."

THE MOOSE MOUNTAIN IRON MINE.

(At Sellwood Station.)

A railway, a branch of the Canadian Northern, has recently been completed from the main line of the Canadian Pacific a few miles east of Sudbury to the Township of Hutton, in which the Moose Mountain Iron Mine is situated. Moose Mountain is about twenty-five miles north of Sudbury. Ore can now be shipped by rail from the mine. The Canadian Northern, a part of the Sudbury to Toronto branch, is in course of construction to the shore of the Georgian Bay, which will give direct connection between the mine and Lake Huron. The Moose Mountain ore, when the railway is completed, can be laid down on Lake Huron by a shorter rail haul than the Minnesota mines have to Lake Superior. The water route to lower lake ports will be considerably shorter than that from Lake Superior ports and the navigation of the Sault Ste. Marie locks will be avoided.

That part of Ontario which embraces Sudbury and Cobalt contains the greatest known deposits of two out of the three magnetic elements, nickel and cobalt. Moose Mountain illustrates that the third magnetic element, iron, is found here in important quantity. Numerous iron ranges occur in Ontario, among which may be mentioned, from east to west, Boston, Temagami, Hutton, Michipicoten, Animikie, Nipigon, Mattawin, and Atikokan. Most of these ranges are similar, geologically, to the Vermilion range of Minnesota. Little work has been done on these ranges compared with what was required to prove the ore bodies on the United States side of Lake Superior, in Michigan and Minnesota. When the Ontario ranges are properly prospected, by means of

diamond drills and in other ways, it is confidently believed that many ore bodies will be discovered. The three most important iron mines, so far discovered in Northern and Western Ontario, had surface exposures of ore. The Helen Mine of the Michipicoten range on Lake Superior has been a shipper for some years. Moose Mountain, north of Sudbury, and a deposit on the Atikokan range west of Port Arthur are now ready to begin shipping. In southeastern Ontario, where the iron deposits are similar to those of northern New York and New Jersey, mines have been worked at various times, and it would seem that there is an important field here for the magnetic concentration of iron ore, similar to what is being done in New York State. The Mineral Range Company in Hastings County is shipping a high grade magnetite to some of the Ontario furnaces.

The Moose Mountain iron deposit occurs in rocks of Keewatin age, the oldest series of rocks known in this part of the continent. The Keewatin is essentially an igneous complex, the predominent rocks being greenstones. The deposit or deposits at Moose Mountain may be briefly described as follows: On Hill No. 1 there is an exposure of a lense of magnetite 300 feet by 100 feet to 150 feet. The ore has been proved in two drill holes 257 and 400 feet in length, run at angles of 45 and 60 degrees, respectively. This deposit is being worked by a cut which is 75 feet lower than the top of the hill. In line with the larger axis of the lense, W. by N. one-half mile, another large ore body has recently been found 600 feet by 50 feet in size. East by south from No. 1 one-quarter mile, another promising lense is being opened up.

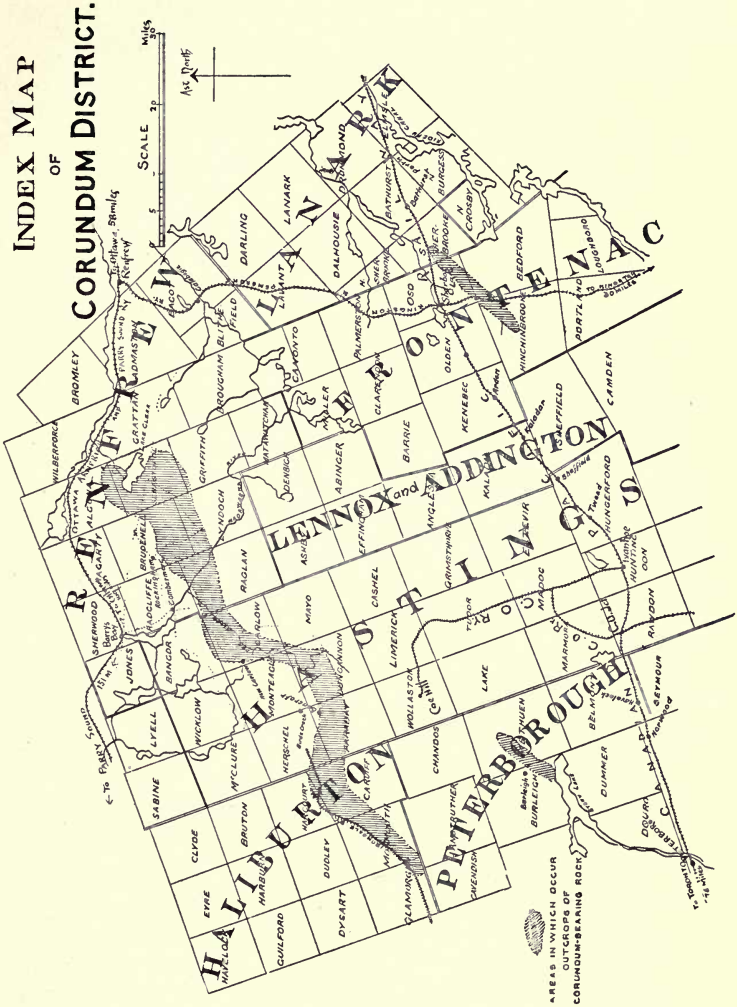
ANALYSES OF IRON ORES FROM THE HUTTON TOWNSHIP RANGES.

No.		% Iron.	% Sulphur.	% Phosphorus.	Titanium.
1	Eugene Coste's sample	51.45	.001	.058	None.
	Prof. Coleman's report	62.64	.066	.011	"
2	Eugene Coste's sample	55.45	.010	.011	"
	Prof. Coleman's report	59.12	.08	.016	"
2	Extension, E. Coste's sample	44.54	.020	.037	"
3	Eugene Coste's sample	59.75	.013	.072	"
	D. D. Mann's sample (Heys' assay)	55.75	None.	.001	"
	" " (Hersey's assay)	53.07	.100	.014	"
4	Prof. Coleman's report	46 08	.06	.094	"
4 (1)	E. Coste's sample	42.76	.015	.036	"
4 (2)	" "	55.24	.015	.055	"
4 (3)	" "	44.19	.002	.011	"
5	" "	31.70	.026	.051	"
6	" "	54.30	None.	.025	"

Sixteen miles north of Moose Mountain a similar iron range is found at Burwash Lake.

THE VERMILION RIVER PLACERS.

Gold has been found in the sands and gravels, over a large area along the Vermilion River. (*Vide* report by A. P. Coleman, Bureau of Mines, Ontario, Vol. X., pp. 151-160.) The railway to the Moose Mountain iron mine at Sellwood Station passes over a part of this area.



This index map was published with the Report on Corundum by Willet G. Miller in the eighth report of the Bureau of Mines of Ontario, 1898. The corundum occurs in different varieties of syenite, especially in nepheline syenite. The mineral is found in anorthosite in the belt shown in the southeast corner of the map. One or two plants are at work extracting corundum from the rock.

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